**Organization(s): Duke University**

**Title:** Flow Visualization for Microflumes: Integrated Analysis and CAD

**Duration of Effort:** July 1998 - February 2001

MTO Composite CAD

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## Objective

(1) Develop new instruments to:
- measure the 3D geometry of finished devices
- visualize flow inside devices
- measure the rate and degree of mixing of fluids
- measure rates of reaction in mixing flows

(2) Validate computational fluid dynamic techniques:
- creeping flows
- interactions between solid surfaces and liquids

(3) Techniques for engineering surfaces
- interior surfaces of channels/devices
- particles

## Progress/Results

(1) Suite if virtual instruments (software + COTS hardware), FlowVIs, released as freeware:
  (a) Particle Image Velocimetry (PIV)
    (i) 1-camera PIV for slow flows
    (ii) 2-camera PIV for broader range of flows, including faster flows
  (c) Quantitative fluorescence
  (d) Particle tracking
  (e) Particle Streaklines
  (f) Interior 3D geometry measurement

(2) Validate computational fluid dynamic techniques:
  (a) Large number of channel geometries simulated with FiDAP and CFD/ACE+
  (b) Both packages compare well with PIV results thus far

(3) Techniques for engineering surfaces:
  (a) Techniques developed for engineering surfaces of flat surfaces
  (b) Novel particles developed (liposomes)

## Status

(1) Instruments we are working on:
  (a) Instantaneous measures of shear rates in flows via fluorescence
  (b) Instantaneous measures of temperature in flows via fluorescence

(2) Continuing validation of CFD with more geometries

(3) Attempting techniques for validation of interior surface chemistry

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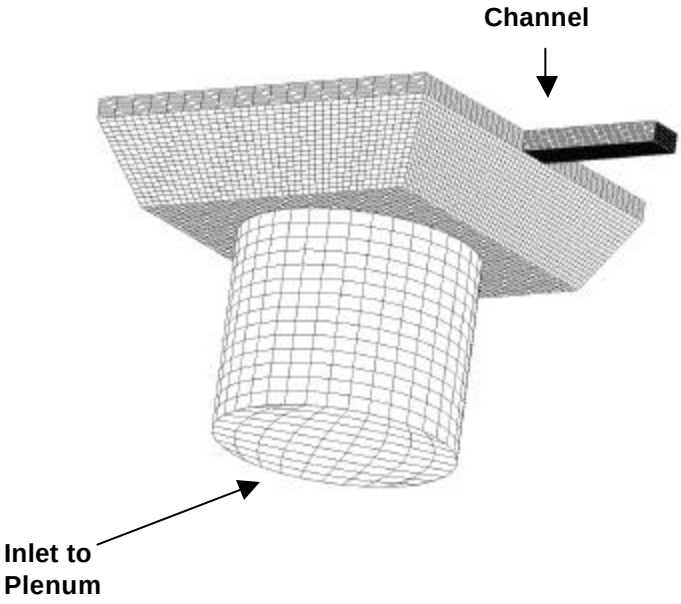
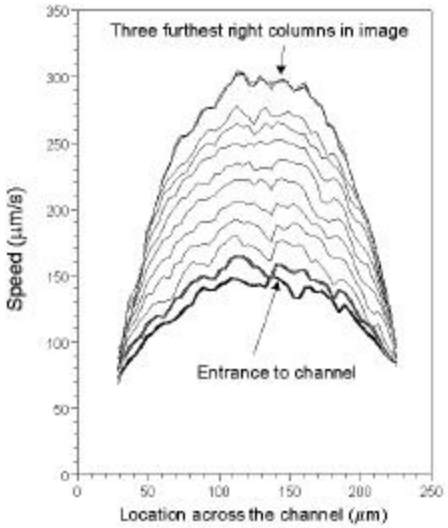
## Wireframe of Plenum – CFD/ACE+

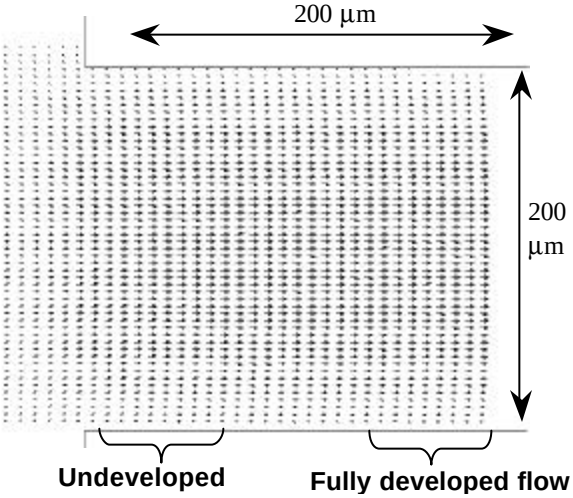



## Velocity profiles at transition from plenum to channel – PIV




## Velocity Field at transition from plenum to channel – CFD/ACE+


## Velocity Field at transition from plenum to channel – PIV




Re = 0.03, maximum velocity = 300 μm/s
Interval separating image pairs = 16.7ms
Exposure = 2 ms
Ensemble average of vector fields from 40 image pairs